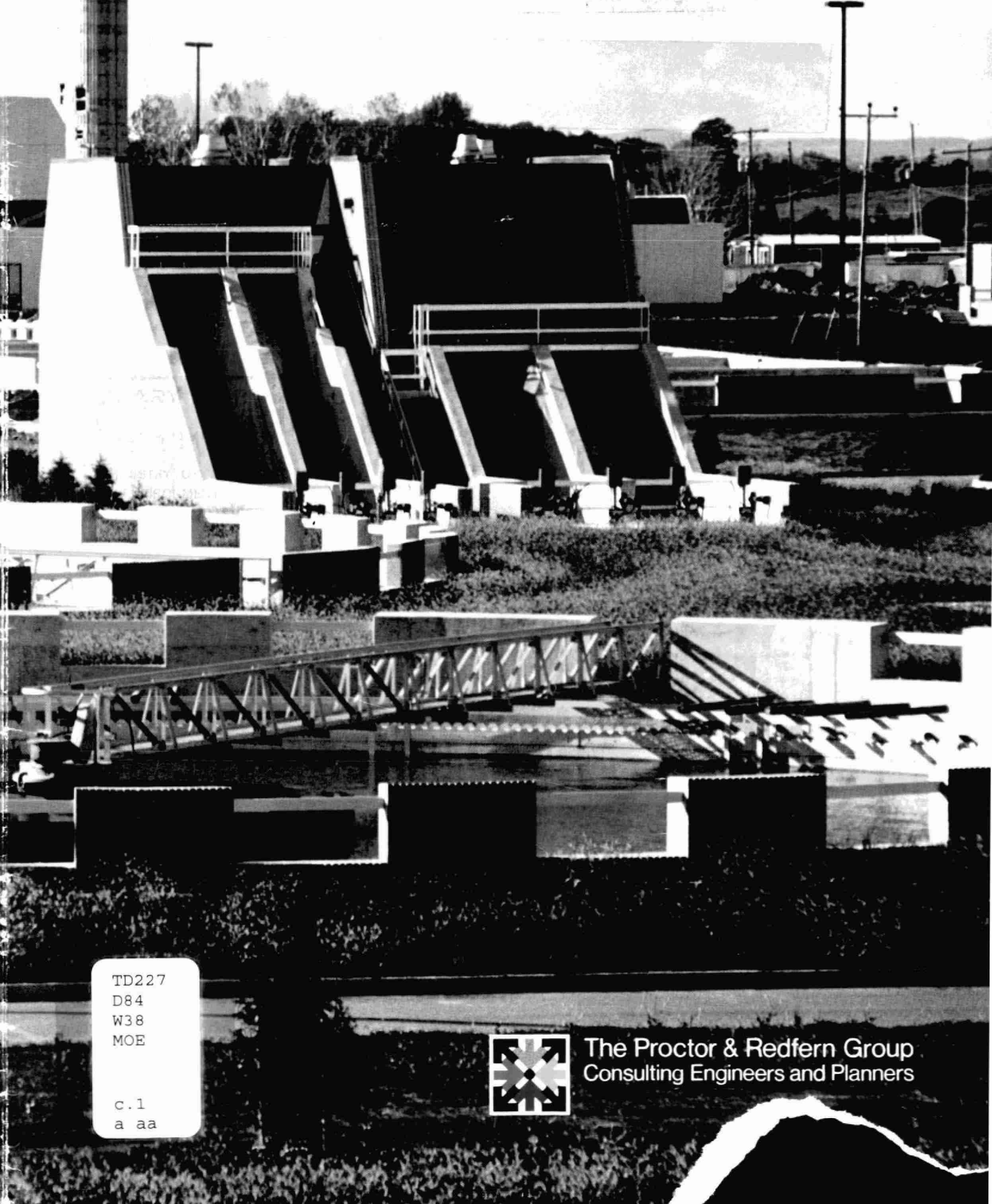




Ministry
of the
Environment

DUFFIN CREEK WATER POLLUTION CONTROL CENTRE



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The Proctor & Redfern Group
Consulting Engineers and Planners

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**The Honourable Harry C. Parrott, DDS.,
Minister of the Environment**

Welcome to the Duffin Creek Water Pollution Control Centre.

This plant and the York-Durham sewage system it serves is a milestone for the Ontario Ministry of the Environment. It caps a quarter century of progress on pollution control in Ontario during which more than four billion dollars has been invested in sewage and water facilities to protect our health and our environment.

This system, which provides serviced room to grow and a healthier environment for the Regional Municipalities of York and Durham, is financed by loans and grants from Environment Ontario and Central Mortgage and Housing Corporation, and planned and constructed by Environment Ontario with close co-operation from the two Regions and Metropolitan Toronto.

Now operated by the Regional Municipality of Durham, this is a leading example of intergovernmental co-operation in preparing for the future.

We take pride in this system and we hope you enjoy your visit.

Harry Parrott

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2

On the north shore of Lake Ontario, near the mouth of Duffin Creek, east of Metropolitan Toronto, the first stage of one of Ontario's largest sewage treatment plants is nearing completion. The Duffin Creek Pollution Control Centre is an integral part of the York-Durham Sewerage Scheme, a project that includes more than 70 miles of trunk sewers, and is the largest sewerage scheme ever financed and constructed by the Ontario Ministry of the Environment.

The scheme was originally conceived in 1963. Rapid deterioration of the water quality in many small rivers draining into Lake Ontario was causing considerable public concern at the time, and the Ontario government responded by commissioning studies to examine the problem.

As a result of these early studies, Proctor & Redfern Limited, Consultants, was engaged by the Ontario Ministry of the Environment, in 1972, to determine the most favourable site for a new sewage treatment plant (in the Duffin Creek area) and to submit a concept plan. Social, environmental and cost factors were all taken into account. Following consultation and hearings before the Environmental Hearing Board, the proposed plant was approved and Proctor & Redfern Limited was engaged to design and implement the construction of the first stage of the project. James F. MacLaren Limited acted as prime consultants on the sewer collection system.

The plant will be built in four stages. Each stage will have a daily treatment capacity of 185,000 m³. Upon completion, several years hence, the ultimate project will have a daily treatment capacity of 740,000 m³.

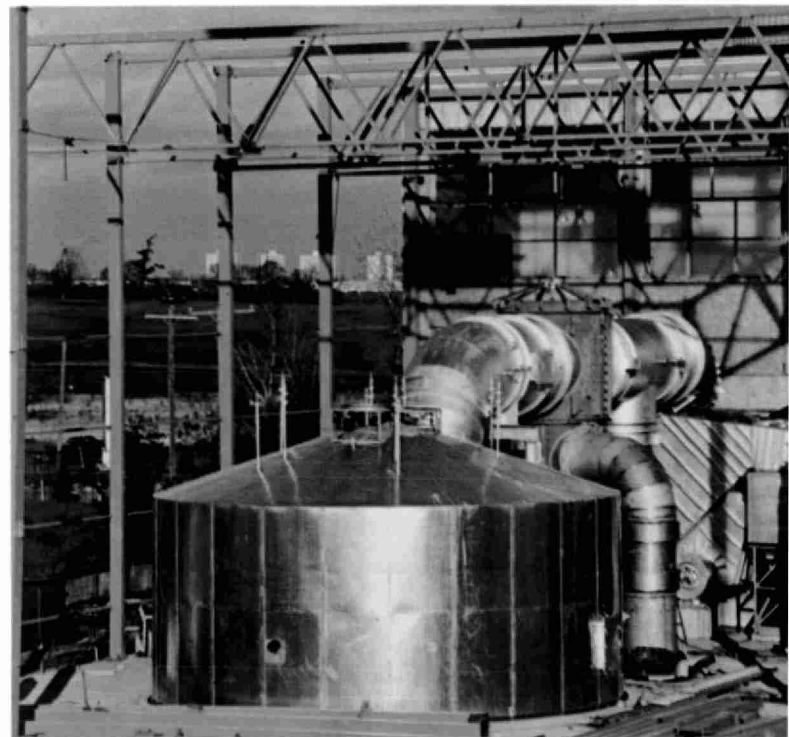
In keeping with the Ontario Ministry of the Environment's concern for environmental quality, the plant's impact on the water quality of Lake Ontario will be minimal and within Ministry guidelines. The plant employs the most up-to-date pollution control technology available and an outfall sewer, about 1,100 metres offshore, ensures that treated effluent is properly dispersed into the lake.

The Duffin Creek Pollution Control Centre incorporates a number of interesting and innovative features to meet both the short and long term water pollution control needs of the York-Durham area:

- The raw sewage screw pumps used at the plant are the second largest in the world, being approximately 3.2 metres in diameter. The world's largest are located in Munich, Germany.
- The vertical sludge screw conveyor (manufactured exclusively by the Spaans Company) is the first one to be used in North America.
- The sludge fluid bed incinerator, used in the plant's energy recovery process, is the largest facility of its type in the world.
- The Stage I buildings and electrical system are specially designed so that they can be expanded in a coordinated rather than a piecemeal way when the additional stages are constructed.
- The computer, electrical and energy recovery systems all contribute to the overall energy efficiency of the plant, a particularly important feature in view of rapidly rising energy costs.
- The plant buildings are designed to be visually appealing as well as functional, and upon completion, the grounds will be attractively landscaped.

The project plan calls for four construction stages. Each stage will have a daily treatment capacity of 185,000 m³. Upon completion, several years hence, the ultimate project will have a daily treatment capacity of 740,000 m³.

The Duffin Creek Plant, financed by the Ontario Ministry of the Environment and funded by the Regions of Durham and York, is operated by the Region of Durham. The cost of Stage 1, excluding land value, is estimated at \$65 million.



Sludge fluid bed incinerator

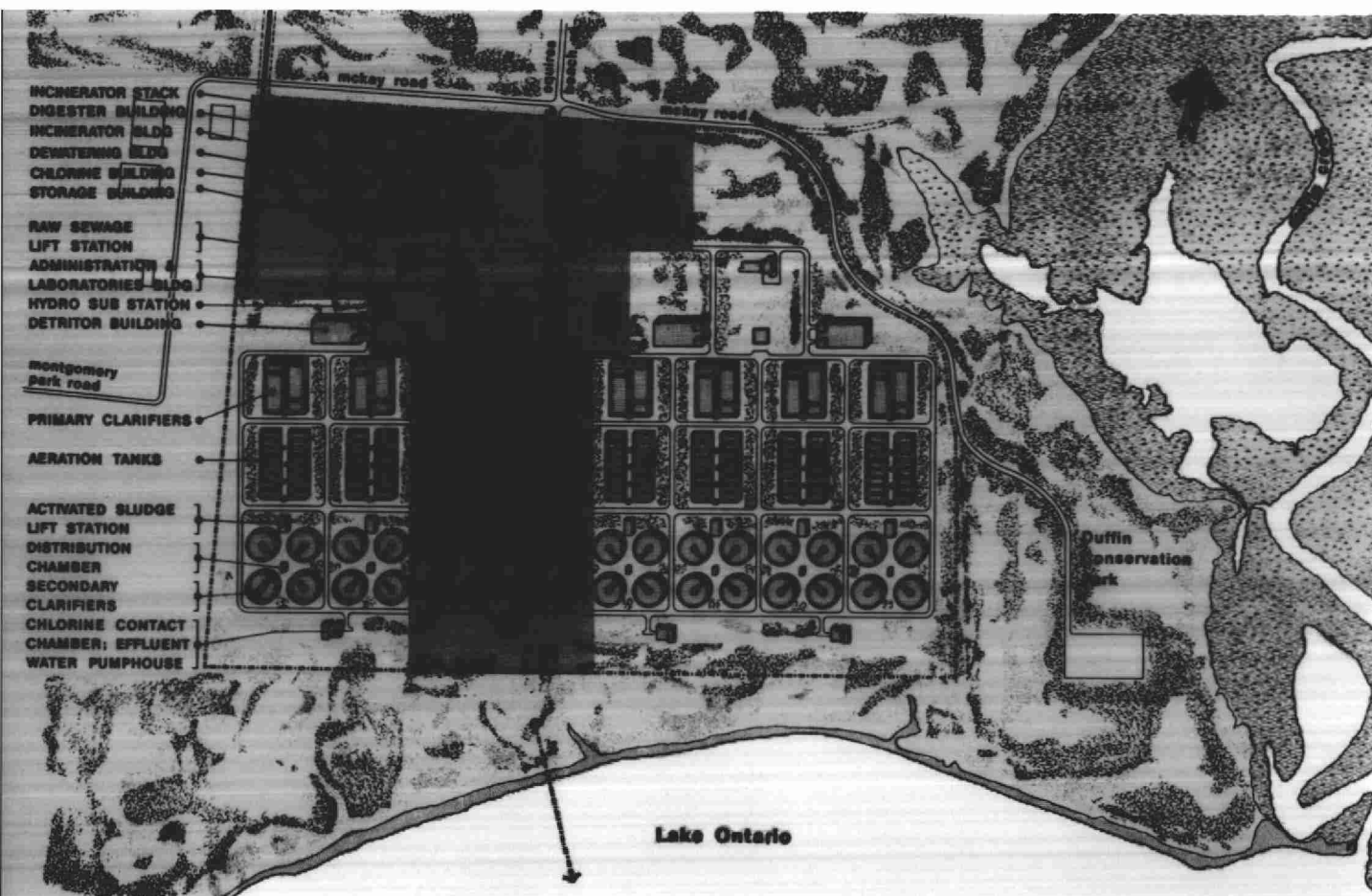


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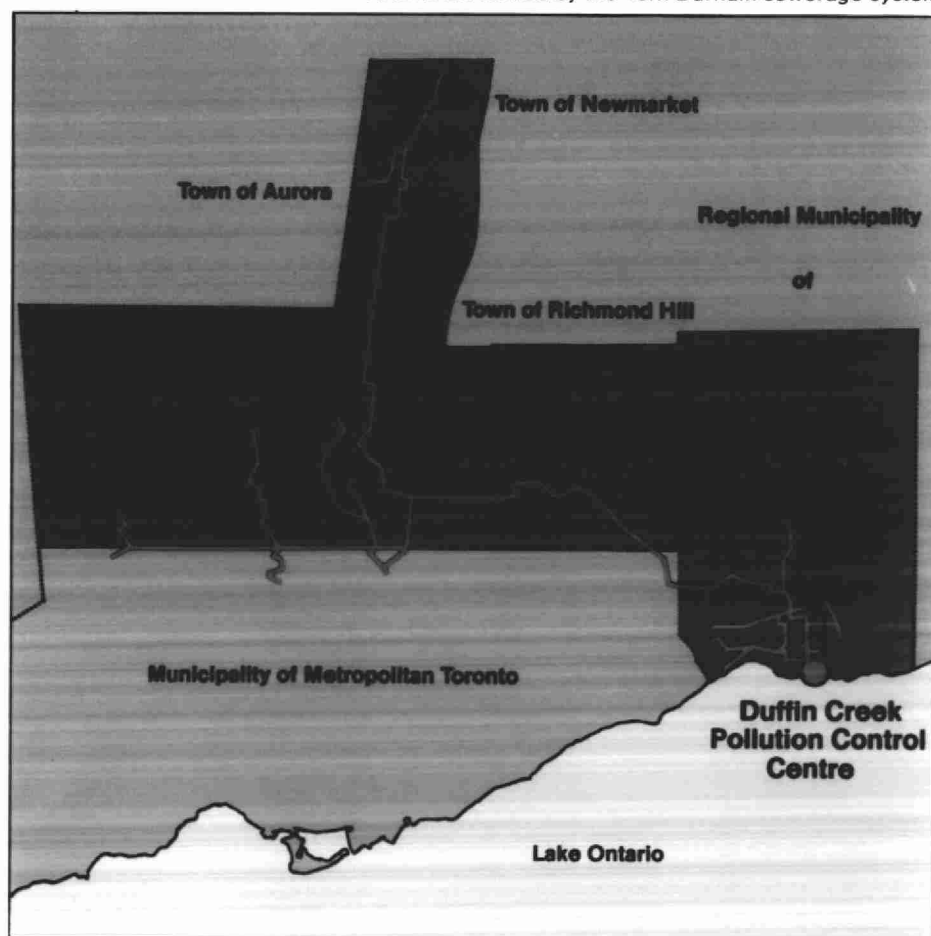
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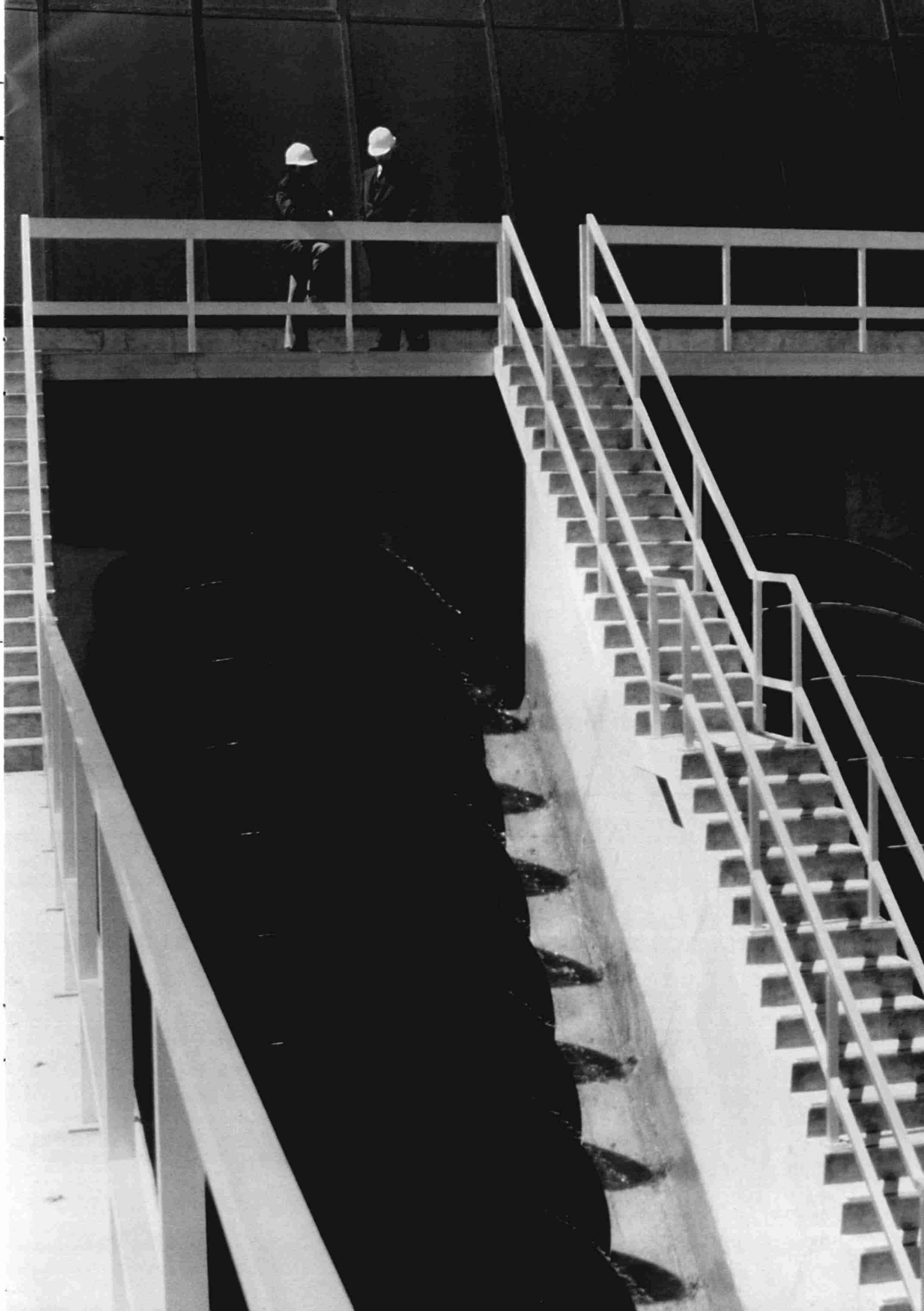
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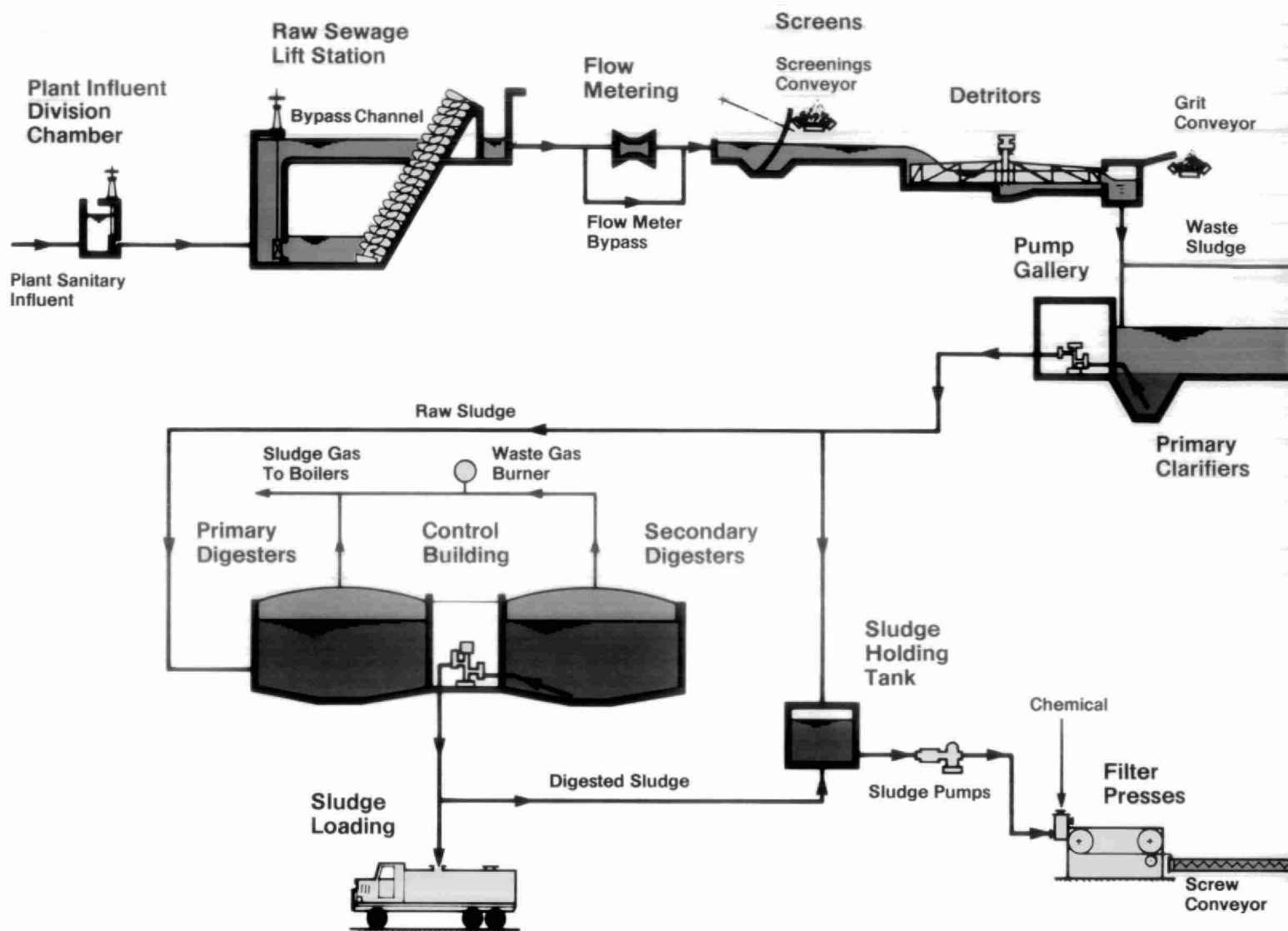


Site Plan—Ultimate stage (160 MIGD)

Area to be served by the York-Durham sewerage system







DESIGN DATA

Design Parameters for Stage 1

Sewage Flow:	Average	189 250 m ³ /d
	Peak	473 125 m ³ /d
Raw Sewage Strengths:	BOD	240 mg/l
	Susp.	
	Solids	270 mg/l

Raw Sewage Pumping Station

3 screw pumps each 3.2 m, total length 15.24 m
 Max. capacity of each pump 236 550 m³/d
 Each pump driven by 335 kW motor

Detritor and Screen Building Screens

No. of screens	6
Make	Shallowmatic
Width	1.83 m

Grit Removal

Type of mechanisms	Detritor
No. of tanks	4
Size of tanks	10.7 m x 10.7 m x 0.8 m

Primary Clarifier

No. of tanks	4
Size of tanks	24.4 m x 54.0 m x 3.7 m
Detention at	
Average Flow	3 Hrs.

Raw Sludge Pumps

No. of raw sludge pumps	12
Capacity	511 m ³ /d
Head	42.7 m

Scum Pumps

Capacity	511 m ³ /d
Head	21.3 m

Aeration Tanks

No. of cells	16
Cell size	22.9 m x 22.9 m x 5.8 m
BOD loading	641 g/m ³
Max. return sludge rate	189 250 m ³ /d
Detention at	
Average Flow	6.4 Hrs.
Drive HP	75 kW

Secondary Clarifiers

No. of tanks	8
Size	41.1 m dia. x 3.7 m
Detention at	
Average Flow	5.14 Hrs.
Overflow Weir	
Rate	233 m ³ /m.d
Rise Rate at	
Peak Flow	44.5 m ³ /m ² .d

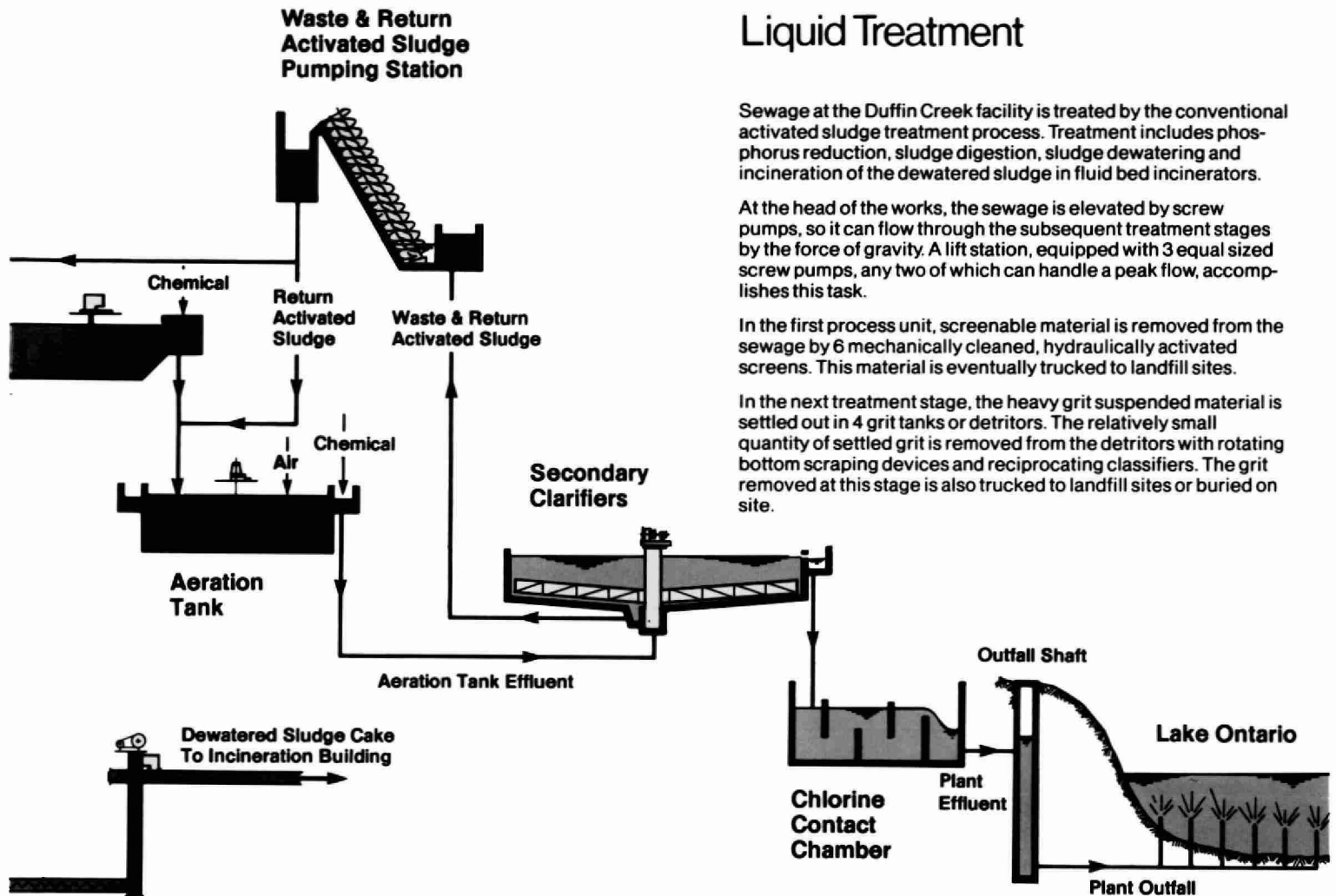
Liquid Treatment

Sewage at the Duffin Creek facility is treated by the conventional activated sludge treatment process. Treatment includes phosphorus reduction, sludge digestion, sludge dewatering and incineration of the dewatered sludge in fluid bed incinerators.

At the head of the works, the sewage is elevated by screw pumps, so it can flow through the subsequent treatment stages by the force of gravity. A lift station, equipped with 3 equal sized screw pumps, any two of which can handle a peak flow, accomplishes this task.

In the first process unit, screenable material is removed from the sewage by 6 mechanically cleaned, hydraulically activated screens. This material is eventually trucked to landfill sites.

In the next treatment stage, the heavy grit suspended material is settled out in 4 grit tanks or detritors. The relatively small quantity of settled grit is removed from the detritors with rotating bottom scraping devices and reciprocating classifiers. The grit removed at this stage is also trucked to landfill sites or buried on site.



Return Sludge Pumps

No. of pumps	4
Capacity of each	47 310 m ³ /d
Diameter	1.7 m
Length of screw	7.7 m

Waste Sludge Pumps

No. of pumps	4
Capacity of each	7 097 m ³ /d
Diameter	1.0 m

Chlorine Contact Chamber

Detention	5 min. at avg. flow
Size of tank	22.3 m x 9.1 m x 3.7 m

Digestion Facilities

No. of primary digesters	2
No. of secondary digesters	2
Size of each	33.5 m x 9.1 m
Volume of each	807 m ³

Digested Sludge Pumps

No. of pumps	4
Type	Duplex Plunger
Capacity	1 192 m ³ /d
Head	15.2 m

Sludge Dewatering

No. of Belt Filter Presses	6
Width of Filter Belts	2 m

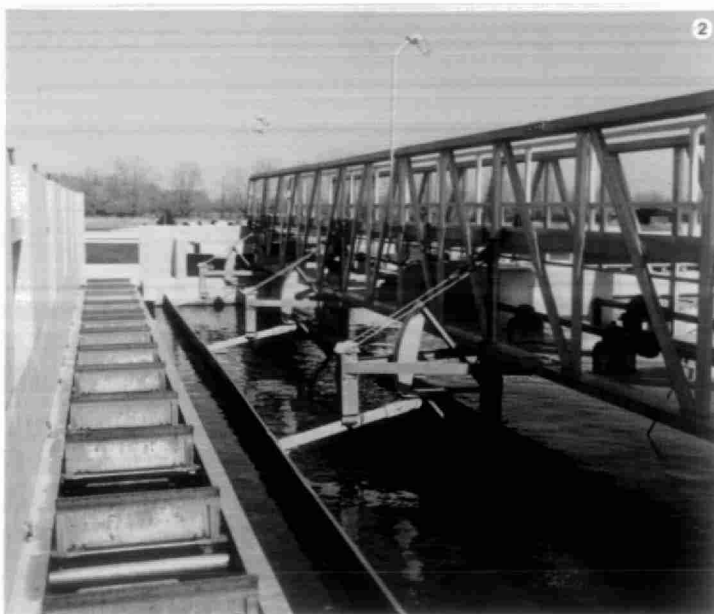
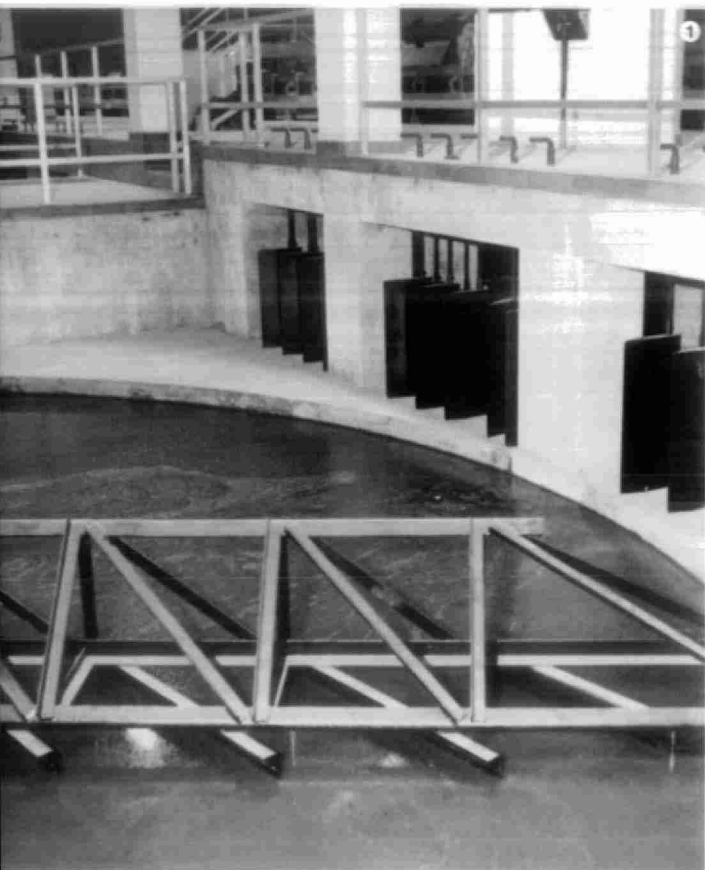
The sewage then passes to primary settling tanks, or clarifiers, where it is held for approximately 3 hours. Each of the 4 rectangular tanks involved are equipped with a travelling-bridge mechanism that scrapes the sludge from the tank bottom and removes surface scum.

Effluent from these primary settling tanks is further treated biologically by the activated sludge process. At this stage, primary effluent is aerated for 7 or 8 hours in aeration tanks. The tanks are broken down into 16 rectangular cells, each cell being equipped with a mechanical surface aerator.

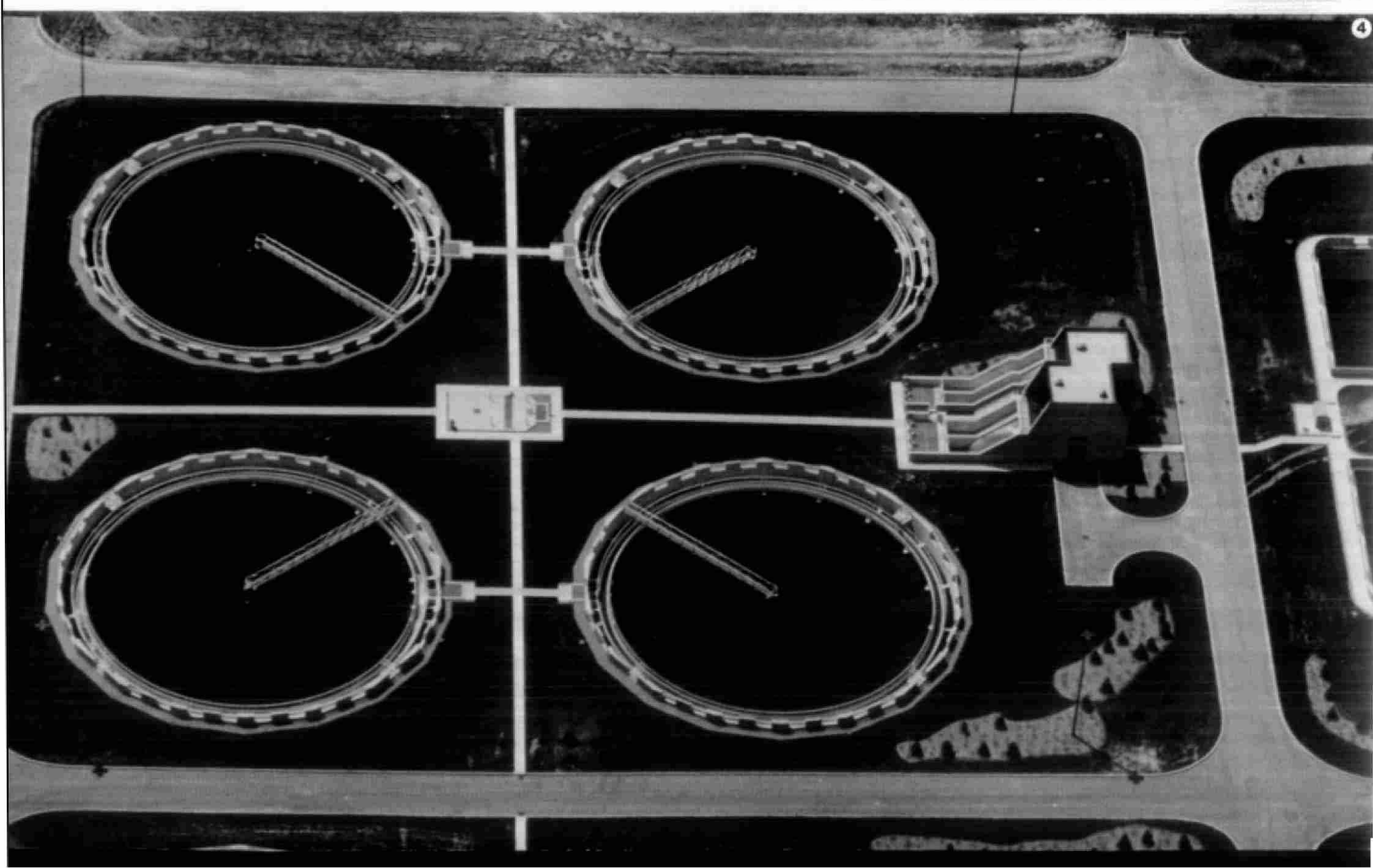
The aerated liquor from the aeration tanks flows to secondary clarifiers (there are 8 in total). Here, the activated sludge material settles out and is removed from the clarifier units by rotating sludge removal mechanisms. Most of the settled activated sludge material is returned, by pumping, to the head of the aeration tanks while the balance is returned to the head of the primary settling tanks for settling out with the primary sludge. Screw pumps are used for both sludge returning and sludge washing.

Most of the clarified liquid or treated effluent from the secondary clarifiers, after disinfection by chlorination, is discharged to the waters of Lake Ontario, 1,100 metres offshore. Some of the treated effluent is used for in-plant purposes such as lawn watering, cooling water in the sludge incineration system and for cleaning the sludge dewatering presses (belt filter presses).

The sludge removed from the primary settling tanks is a mixture of primary and waste activated sludges. It is dewatered, either in a raw state or after being treated in digesters, by belt filter presses. The resulting sludge cake is incinerated.



- 1 Scum baffle and raised arms—primary clarifier
- 2 Launderers on primary clarifiers showing scum board.
- 3 Aeration tank and bridge.
- 4 Secondary clarifiers and activated sludge lift station.



Sludge Treatment

The waste activated sludge from the secondary clarifiers is pumped to the head of the primary settling tanks for settling out with the primary sludges. The combined sludges from the primary settling tanks are pumped either directly to sludge dewatering or, indirectly, after treatment by anaerobic digestion.

The sludge anaerobic digestion facility consists of two primary and two secondary digesters together with a centrally located digester control building. The primary digesters have fixed steel roofs, while the secondary digesters are provided with steel floating gas holder covers.

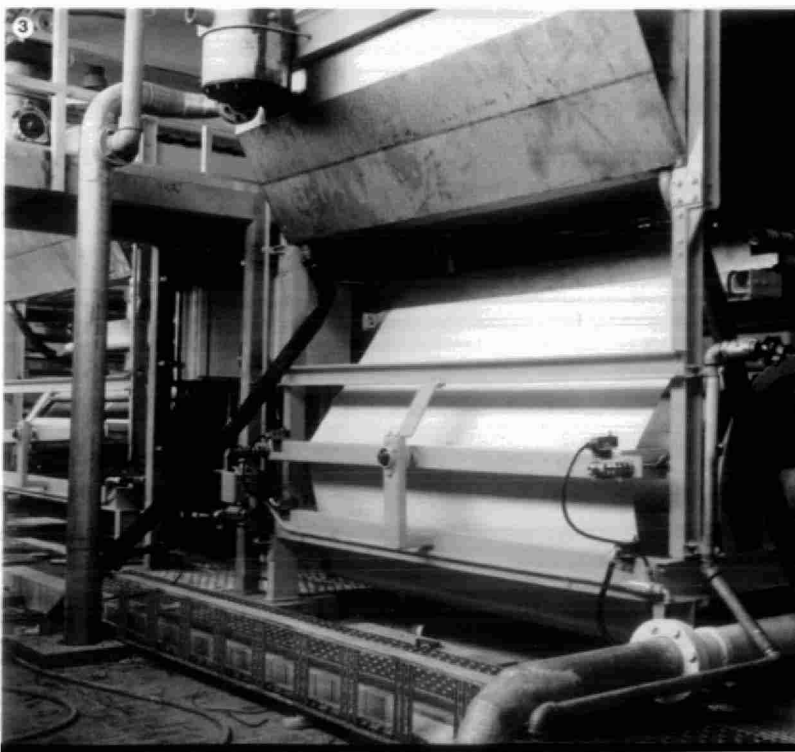
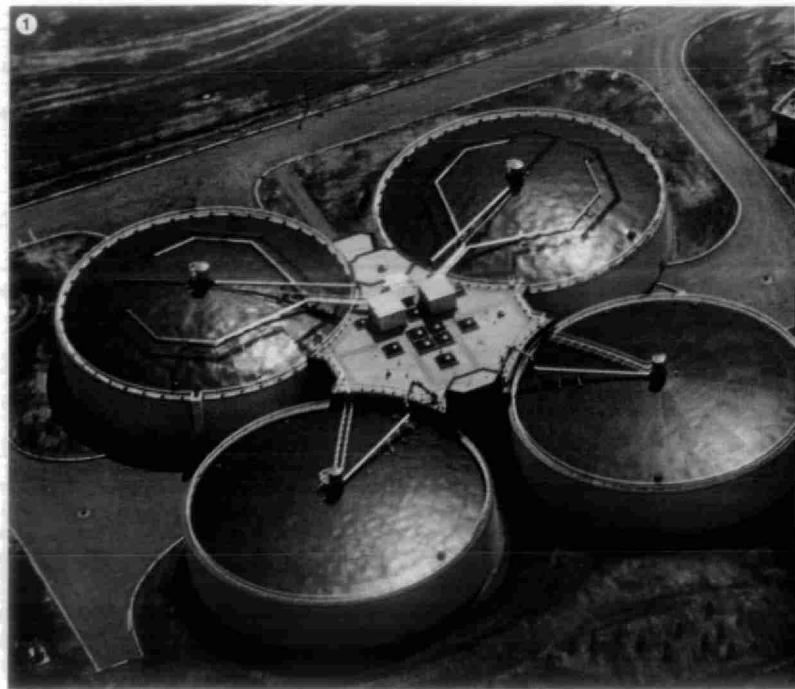
The pumping of sludge out of the primary clarifiers is controlled by monitoring the density of the sludge. Only sludge above a certain solid content is transferred.

The raw sludge from the primary settling tanks or digested sludge from the digestion tanks is taken to sludge storage tanks, prior to dewatering. After passing through macerating devices that cut up the grosser solids, the sludge is pumped to a battery of belt filter presses for dewatering. There are six belt filter presses in all, each with belts 2 metres wide and featuring straining, low pressure and medium pressure zones.

The dewatered sludge cake that is discharged from the presses is transported to the incinerators by an enclosed screw conveyor system which includes a unique vertical screw section. The filtrate water resulting from the dewatering process is mixed with plant effluent and then used as backwash water to clean the belts.

The raw sludges are delivered to the primary digesters where they are first heated by circulating through straight-tube type external heat exchangers and then mixed by internal mixing guns. Next, the sludge passes from the primary to the secondary digesters.

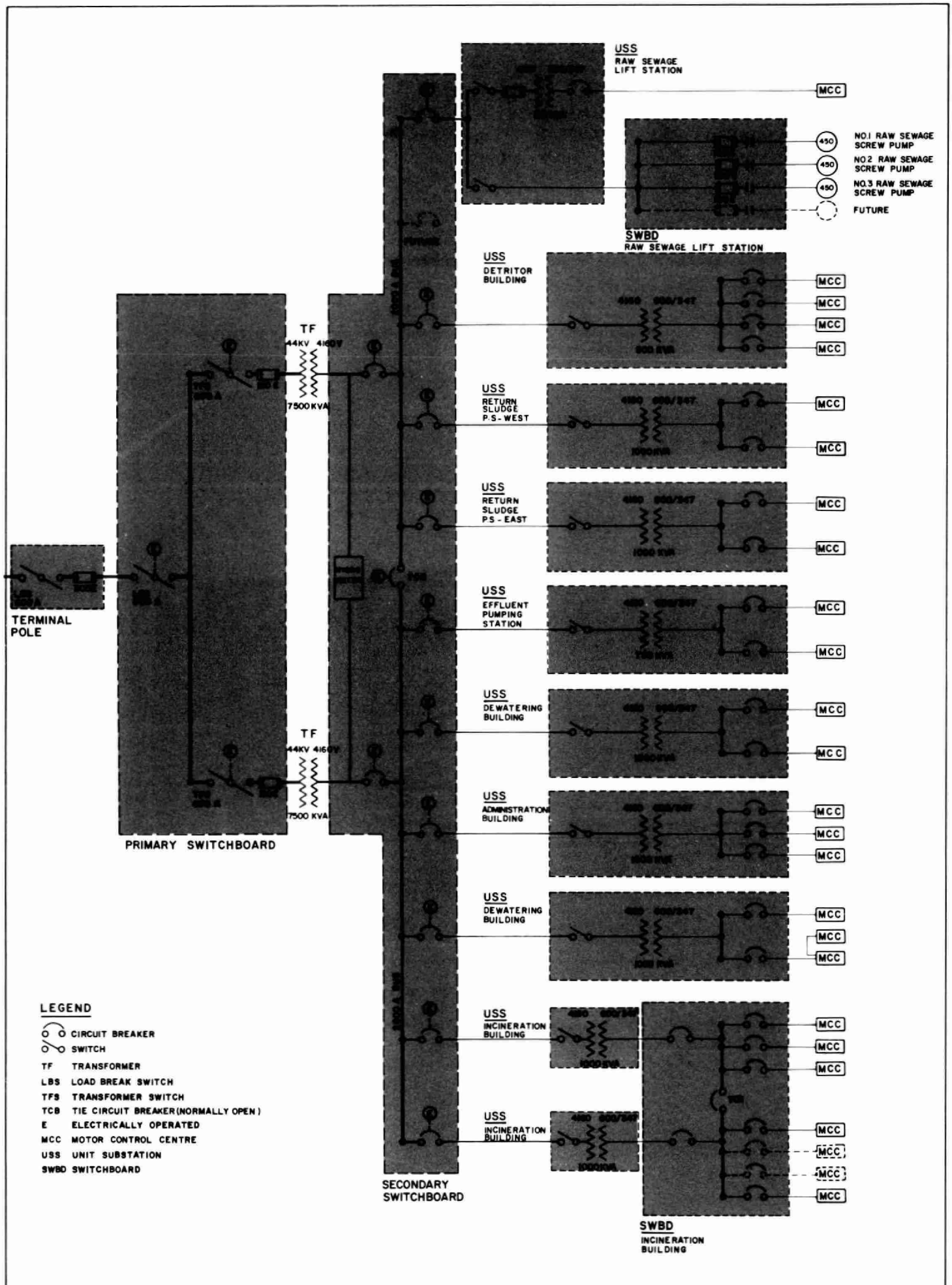
Methane gas, which is generated in the digestion process, is collected under the floating gas holder covers of the secondary digesters. After pressure boosting, the collected gas is used to fire the boilers that provide heat for space and digester heating. Any surplus gas is used in the sludge incinerators.



1 Primary and secondary digesters and the central digester control building.

2 Floating cover of one of the secondary digesters—under construction.

3 One of the battery of 6 belt filter presses.



Electrical Distribution and Supervisory Systems

A pollution control plant the size of Duffin Creek requires a sophisticated electrical distribution and supervisory system that is reliable, flexible, and energy-efficient, yet powerful enough to handle the heavy demands made upon it. The accompanying diagram illustrates the basic structure of the Duffin Creek electrical system.

Electricity is supplied to the plant by Ontario Hydro through an overhead 44,000 volt system. Power enters the plant through a Load Break Switch situated at the plant's property boundary. From there it travels underground via a duct bank and manhole system to a centrally located main substation which has been designed to accommodate the power requirements of both the first and second phases of the project. The third and fourth phases will be serviced by a second main substation. Together, both substations would have the capacity to supply 4,000 homes with electricity.

Incoming power is reduced (from 44,000 volts to 4,160 volts) by two transformers that lie adjacent to the primary switchboard. The electricity then passes through a secondary switchboard. From there it is distributed throughout the plant, via feeders, to strategically located unit substations. At each substation, the power is transformed to a lower voltage (600) so that the plant motors and associated equipment are supplied at the proper level.

The duct bank system distributing the power throughout the plant, can accommodate an eventual link up with a future, second 44,000 volt supply line. This second supply line will service project phases 3 and 4 and will also provide a back-up supply to the entire plant. Parallel, but physically separate from this duct bank system is a second duct bank system containing wires for telephone, instrumentation, outdoor lighting, remote monitoring and control systems.

A network of ground rods are present at the main substation with resistor grounding at each transformer. In addition, feeders from both the secondary switchboard and the main 44,000 volt feeder can handle 133% of the normal voltage. Through this grounding system, the plant can operate on a single phase ground fault for up to 1 hour, thus allowing the maintenance staff to isolate and correct problems without having to first shut down all or major portions of the electrical network.

The lighting system utilizes two voltage levels — 347 volts for outdoor and high ceiling fixtures and 120 volts for indoor low ceiling fixtures. The majority of lighting fixtures are the high pressure sodium type which produce significantly more illumination per watt of power consumed than the mercury vapour, incandescent or fluorescent types.

An advanced computer monitoring and control system forms an integral part of the operational design of the plant. It consists of a host computer, Central Processing Unit and four Smart Remote Terminal Units (SRTU) situated at key locations throughout the plant.

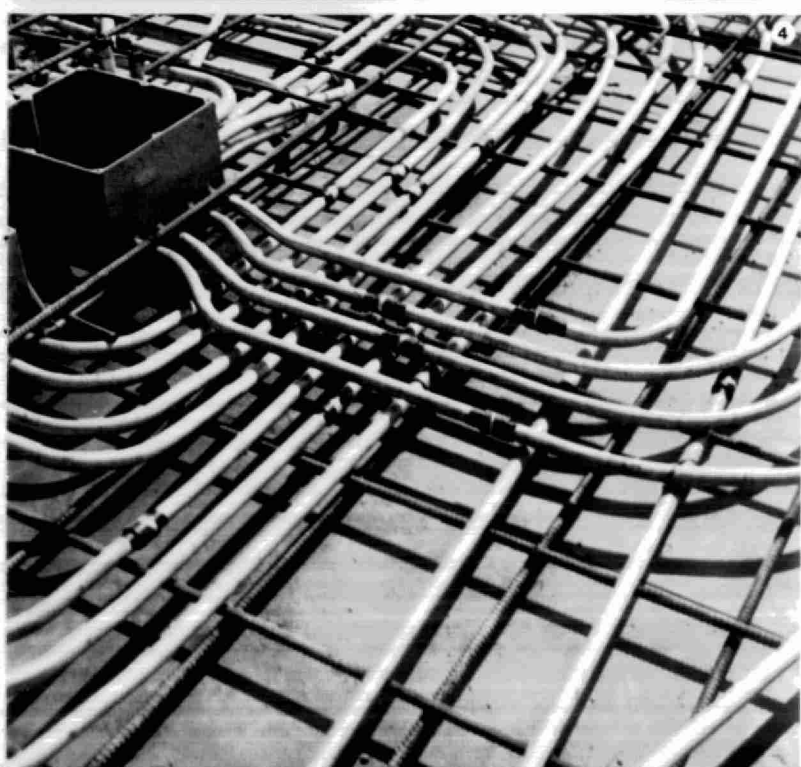
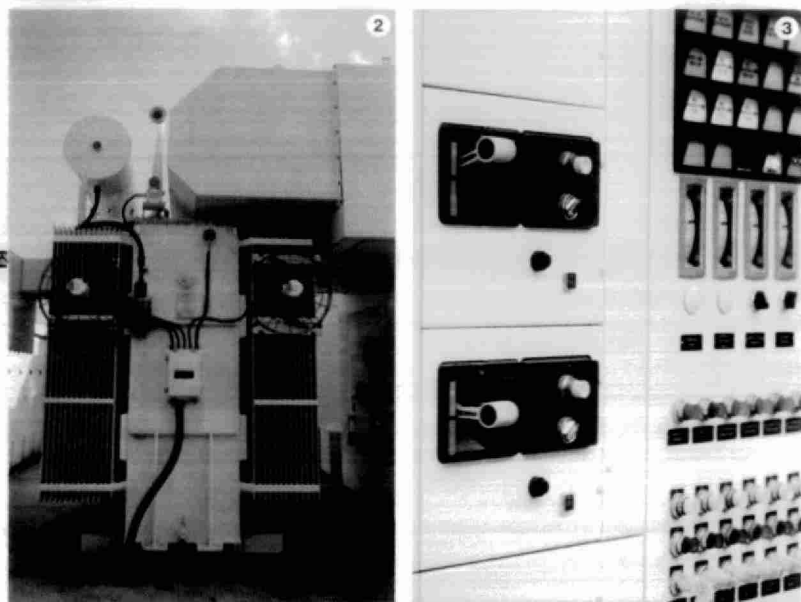
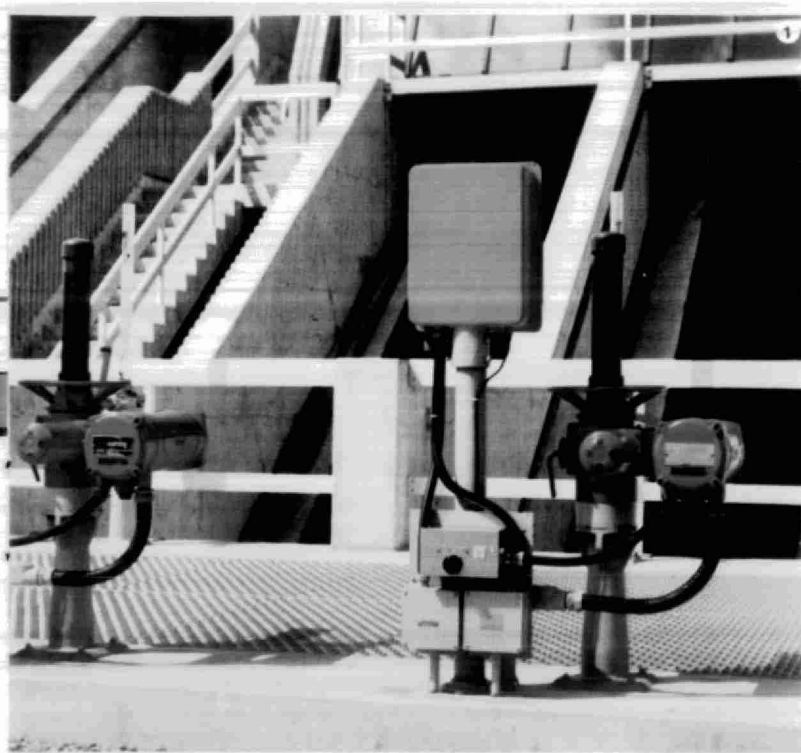
Several different jobs are performed by the computer system including monitoring and control of plant operations, maintenance of plant machinery (it notifies personnel of required maintenance tasks), indication of discrete motor status (it shows if any particular motor is running or not), indication of malfunctions through an alarm system and a peak electrical power load shaving system. This latter capability maximizes the efficient use of electricity by ensuring that when a peak power load is approached, electricity is supplied to only those areas which have been previously designated as priority functions.

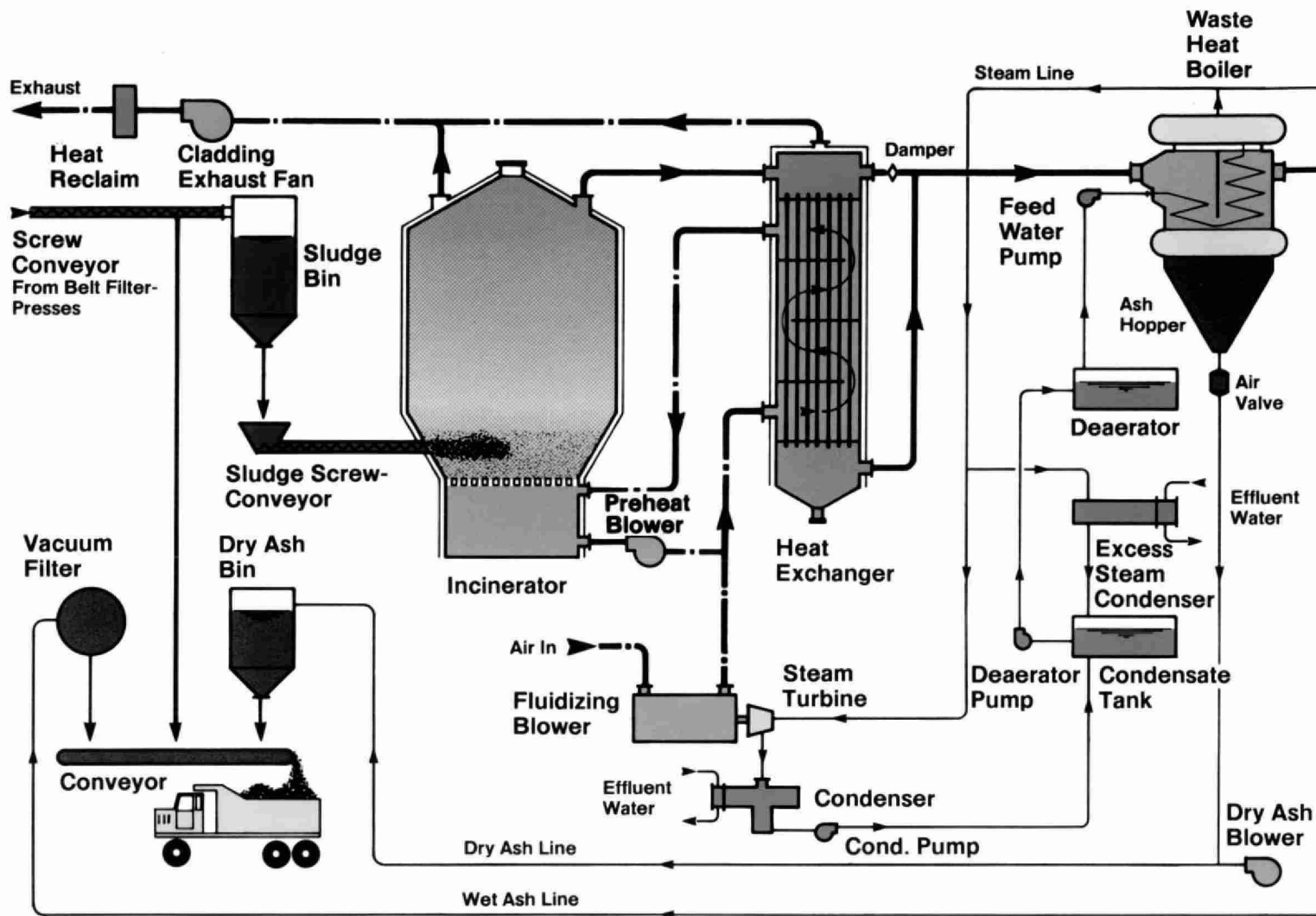
1 Return sludge flow transmitter (yellow) and electric motor operating sluice gate of the activated sludge lift station.

2 Main power transformer — 44,000 volts to 4160 volts.

3 Motor control incorporating local alarm annunciator and instrumentation — incinerator building control room.

4 Typical conduit entry into a motor control centre, prior to pouring concrete floor.





Fluid Bed Incinerators (Dorr-Oliver Canada Limited)

bed dia. (bottom/top)	5 600 mm/6 200 mm
fluidized bed depth	1 500 mm
freeboard dia. (i.d./o.d.)	8 535 mm/9 250 mm
effective freeboard height	4 875 mm
refractory walls	225 mm firebrick, 115 mm insulating block, 100 mm exterior annular convection space
sand particle size	3-4 mm
feed system	2 screw feeders @ 300 x 200 mm (provision for 2 future)
auxiliary fuels	No. 2 oil @ 45 325 J/g and anaerobic digester gas @ 22 400 kJ/m ³

@ Design Point¹

feed rate	72.575 kg/s @ 70% moisture
heat release	19 700 kW
freeboard retention time	greater than 5 s
windbox temp. ²	370°-425°C
freeboard temp.	860°C
excess air	30-40%
combustion air ³	7.9 Nm ³ /x @ 40 kPa

NOTES:

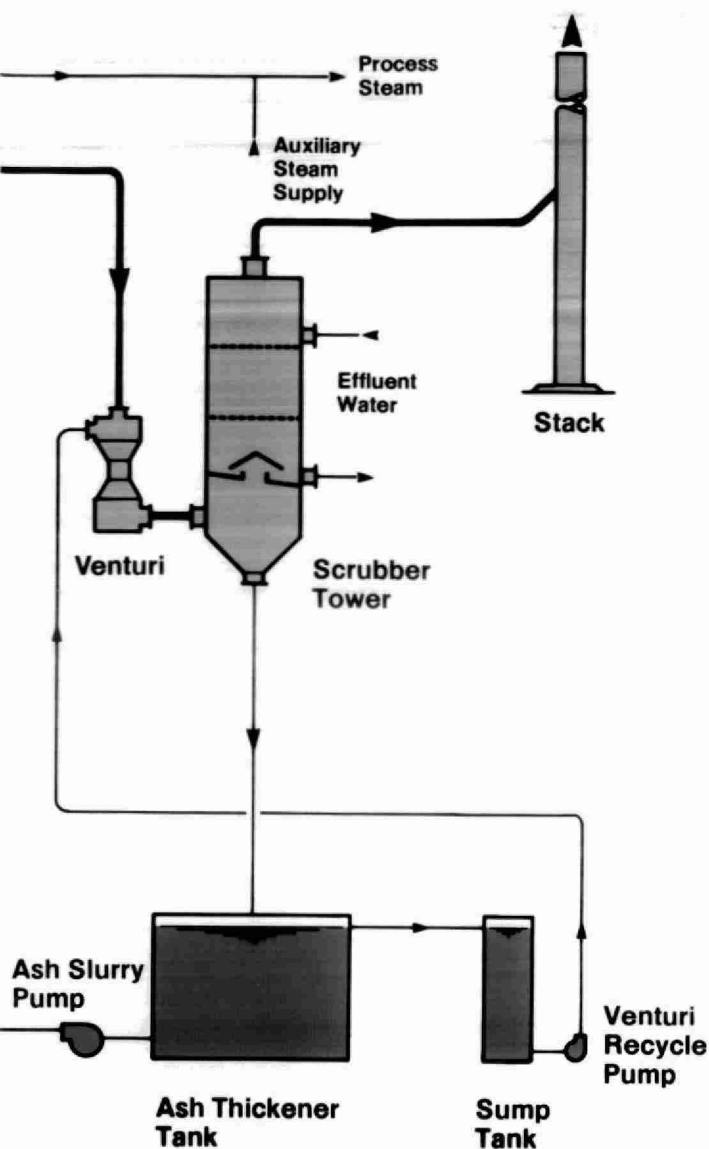
- Design point sludge cake assumed to consist of 76.67% volatiles at 21 222 kJ/kg and 23.33% inerts. Volatiles consist of a mixture of sludge and fibrous pulp solids.
- 1 250°C maximum temperature when burning auxiliary fuel in hot windbox in conjunction with combustion air preheat.
- Combustion air blower—Spencer 8 stage centrifugal blower with a 2 stage 485 kW, 4 500 Hz, Terry steam turbine drive.

Waste Heat Boilers (Foster Wheeler Limited)

gas flow	12.4 kg/s
gas temperature (in/out)	683°C/260°C
steam rate	3.54 kg/s
steam pressure	1 900 kPa (3 500 kPa future design)
feedwater temperature	175°C
steam temperature	210°C
average heat flux	24.29 kW/m ² finned tubes 5.68 kW/m ² bare tubes
tubes— size	63.5 mm o.d. x 2.667 mm MW tubes
— number	320 @ 114.3 mm c-c parallel grid
— material	SA-178-A
— fins	88.9 mm o.d. x 1.524 mm @ 12.7 mm c-c, spiral wound
— surface	311.32 m ²
— soot blowers	6 @ 6 kg per 40 s cycle each and 1 825 kPa steam pressure

Economizer (Enerex Inc.)

gas flow	12.4 kg/s
gas temperature (in/out)	260°C/205°C
feedwater flow	3.54 kg/s
feedwater temperature (in/out)	121°C/175°C
average heat flux	4.42 kW/m ²
tubes— size	44.45 mm o.d. x 3.81 mm tubes
— number	8 circuits (serpentine) on a 98.425 mm c-c parallel grid
— material	SA-178-A
— fins	69.85 mm o.d. x 1.524 mm @ 8.467 mm c-c, spiral wound



- surface 202.7 m²
- soot blowers 2 @ 60 kg per 40 s cycle each and 1 825 kPa steam pressure

Air Preheater (Canadian Shack Limited)

gas flow	11.34 Nm ³ /s
gas temperature (in/out)	860°C/572°C
air flow	7.29 Nm ³ /s
air temperature (in/out)	37.8°C/578.3°C
overall heat transfer coefficient	39.05 W/m ² °C
tubes— size	114.3 mm o.d.
— number	171.45 mm staggered centres
— material	321 stainless steel
— fins	none
— surface	331 m ²
— soot blowers	none

Venturi Scrubber (Ducon-Mikropul Limited)

Venturi:	wetted wall variable throat venturi
gas flow	11.72 kg/s
gas temperature (in)	205°C
adiabatic saturation	78.9°C
water (in)	14.95 L/s @ 76.7°C
water (out)	14.51 L/s @ 78.9°C
cooling tower:	2 cooling trays
gas flow in	12.17 kg/s
gas temperature (in/out)	78.9°C/50°C (saturated)
water in	44.29 L/s @ 15.55°C (saturated)
water out	47.70 L/s @ 62.78°C

Incineration

The incineration/waste energy complex at the Duffin Creek plant is housed in the Incineration Building. The building contains fluid bed incinerators, waste heat recovery boilers, auxiliary steam boilers for start-up and emergency use, plant process and building heating services, air pollution scrubbing systems and a 62 metre high incinerator chimney.

When dewatered sludge is transported to the incinerator building, via screw conveyors, it is initially stored in sludge storage bins. From there it is carried to the incinerators by variable speed sludge screw feed mechanisms.

Each incinerator has a sand bed that contains 68 tonnes of dry, hard silica sand. The sand bed is fluidized by combustion air that is blown through tuyeres into the incinerator chamber. Sludge entering the incinerator is initially broken up by the grinding action of the sand and then partially incinerated in the fluid bed. Water vapour from the sludge, along with the products of combustion, pass to the top of the incinerator where final combustion occurs at 860°C. Here, odours and contaminants are destroyed by the high temperature.

The gases then pass into the top of the vertical heat exchanger where they either bypass or pass down through the heat exchanger tubes. Incoming combustion air can be heated up to 578°C through the heat exchanger. This preheated air is, as described above, blown into the sand bed of the incinerator.

Methane gas from the digester can be burned in the hot windbox (located below the sand bed plate) to raise the temperature of the combustion air to 1,250°C if higher temperatures are required to achieve autogenous combustion of the dewatered sludge.

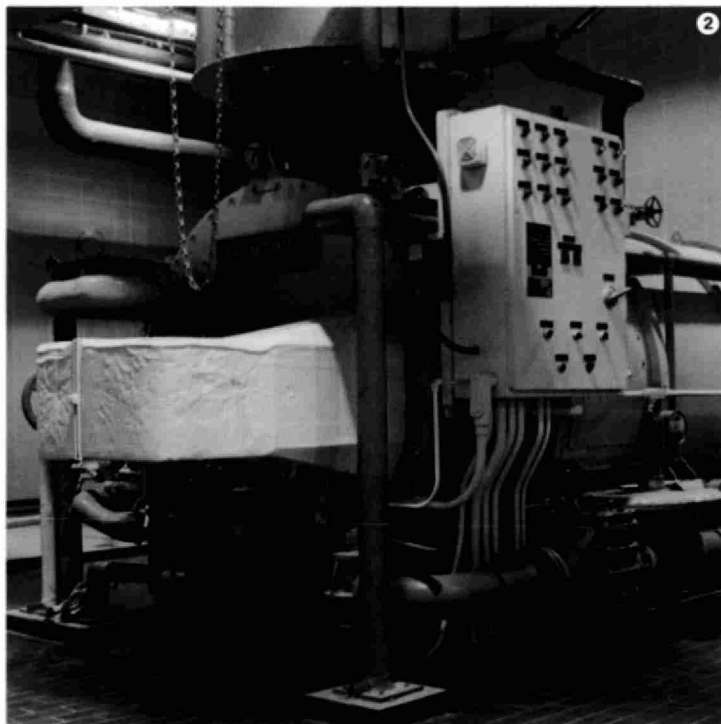
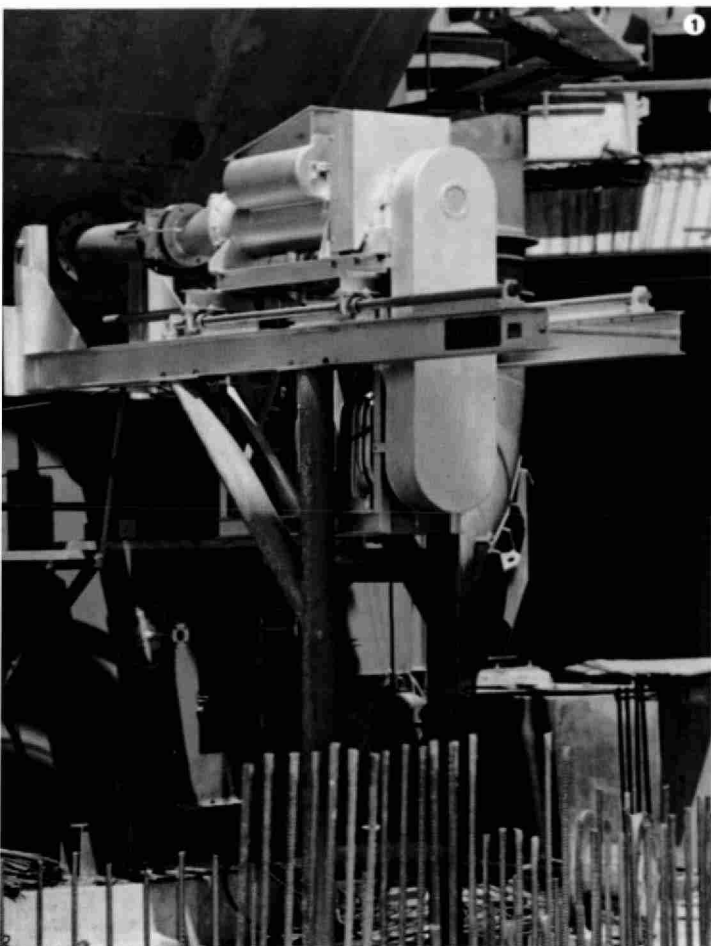
After passing through the heat exchanger, the combustion gases go to the waste heat boiler where steam is generated. Some of the steam is used to drive the 485 kw steam turbines that power the combustion air blowers. Excess steam is used for other purposes including space heat for the buildings and heat for the digester. Future plans call for the use of excess steam in the generation of electricity to power the plant's aeration process.

The gases leave the waste heat boiler at 205°C and enter the venturi scrubber where entrained particulate matter is removed and the gases are cooled to 79°C.

When the gases reach the scrubber's cooling tower, the temperature is lowered again, this time to 50°C. Much of the moisture content of the gases is also removed at this stage before they are finally exhausted up the chimney. Cooling water, used to absorb the heat from the combustion gases, is heated to 65°C in the process and could be used at a later stage as a source of heat for anaerobic digestion.

Use of recycled energy will be limited until 1985 because of the relatively low volume of sewage processed by the plant. In future stages, the anaerobic digesters will be heated from the cooling tower water recovered waste heat, and excess steam from the incinerator waste heat will be used to produce electric power to, for example, run the aerators and dry sewage sludge.

The Stage I works can be expanded to accommodate a total of 4 incinerator systems and two 2,000 kw steam turbine generators. In place of future incinerators, sludge dryers utilizing waste heat directly or steam, may be installed to produce dried sludge soil conditioner.



1 Screw feeder for reactor.

2 Auxiliary boiler.

3 62 metre incinerator stack and incinerator building.



Acknowledgements

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